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学位論文題名	Study on Tensile Behavior and Failure Mechanism of CFRP Grid-Sprayed Mortar in Strengthened Concrete Structures (コンクリート構造物の補強におけるＣＦＲＰ格子筋の引張挙動ならびに耐荷メカニズム)
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【論文の内容の要旨】

Strengthening method by CFRP grid-sprayed mortar has been applied for concrete structures in Japan. It is clear that ensuring the integrity of the CFRP grid-sprayed mortar and existing concrete is essential to the good strengthening effect for concrete structures. The past researches mainly focused on the bond behavior between the strengthening material (CFRP grid and sprayed mortar) and the existing concrete. It is necessary to investigate the interaction behavior between the CFRP grid and mortar. In this study, the tensile behavior of the CFRP grid-sprayed mortar in strengthened concrete structures was selected as the research object. The main contents of this research can be summarized as below.

Chapter 1 Research background. This chapter introduced the necessity of strengthening and main strengthening methods for concrete structures. The basic properties of the CFRP grid, sprayed mortar and the construction procedure of strengthening method by CFRP grid-sprayed mortar were introduced emphatically.

Chapter 2 Past researches. This chapter ascertained the key issues to be solved in this thesis through the literature review and then determined the research purposes, research contents and the technical route. The direct relative past researches on the bond behavior between the strengthening material and the existing concrete were introduced in detail.

Chapter 3 Tensile behavior and failure mechanism of the crossing point in CFRP

grid. As a mesh-type structural material, the crossing point seems to be the weak part in CFRP grid. In order to clarify the tensile behavior of the CFRP grid-sprayed mortar in strengthened concrete structures, it is necessary to investigate the tensile behavior of the crossing point in CFRP grid firstly. This main contents of this chapter were composed of two parts. The first part was to investigate the tensile behavior of the single crossing point in CFRP grid based on pull-out tests. Five types of CFRP grids were selected to conduct pull-out tests. The maximum tensile load, failure mode and load-displacement relationship of the crossing point in CFRP grid were analyzed. The second part was to investigate the tensile behavior of multiple crossing points in CFRP grid through the further analysis of past researches. Strain differences on the two sides of the crossing point along the vertical bar in CFRP grid were calculated and analyzed. The following main innovative results were achieved: (1) Two mechanical models (Elastic Layer Model (ELM) and Spring Model (SM)) of the crossing point in CFRP grid were proposed. Based on the proposed models, the tensile behavior and failure mechanism of the crossing point can be clarified clearly. (2) The influencing mechanism of the mortar on the tensile stress transfer mode of multiple crossing points along the vertical bar in CFRP grid was revealed. (3) The failure mechanisms corresponding to different failure modes of pull-out specimens with multiple crossing points were revealed.

Chapter 4 Tensile anchorage mechanism and bidirectional intersect-type anchorage behavior of CFRP grid in mortar. The main contents of this chapter were composed of two parts. The first part was to investigate the anchorage mechanism of CFRP grid in mortar based on pull-out tests. Types of CFRP grids, grid interval, number of nodes and anchorage conditions were selected as changing parameters to conduct pull-out tests. The maximum loads, failure modes, load-displacement curves were obtained. The tensile strength utilization of CFRP grid, growth gradient of maximum load, characteristics of bond action and resistant, tensile bearing mode of resistant action, coupling process between bond action and resistant action were analyzed. The second part was to verify the feasibility of a new anchorage method named intersect-type anchorage method of CFRP grid in mortar based on bidirectional pull-out tests. The maximum loads, failure modes and strains of the CFRP grid in the intersecting part were obtained. The tensile strength utilization and failure mechanism were analyzed. Based on the analysis of two stages of pull-out experimental results, the following main innovative results were achieved: (1) The minimum number of nodes for full use of the tensile strength of CFRP grid was obtained; (2) The tensile bearing mode of CFRP grid with multiple nodes and the corresponding calculation formula of the maximum tensile

load were proposed; (3) The coupling mechanism between bond action and resistant action was revealed; (4) A new anchorage method named bidirectional intersect-type anchorage method of CFRP grid in mortar was proposed. The main procedure of this new method is cutting the middle part of the horizontal bar between two adjacent vertical bars and assembling two parts of CFRP grids by intersecting with a certain number of nodes.

Chapter 5 Tensile and confining behavior of the CFRP grid-sprayed mortar in strengthened concrete cylinders. It is known that the CFRP grid-sprayed mortar in strengthened concrete columns would bear the circumferential tensile stress under the vertical compressive load. In order to reveal the strengthening mechanism of concrete columns by CFRP grid-sprayed mortar, it is necessary to investigate the tensile behavior and confining mechanism of the CFRP grid-sprayed mortar firstly. It is clear that the tensile performance of the CFRP grid and mortar are obviously different. However, they should work cooperatively as a type of composite substructure to provide the confining action for concrete along with the circumferential tensile process. In this chapter, three kinds of strengthening materials (CFRP grid, welding steel mesh and CFRP sheet), different kinds of anchorage methods and anchorage length were selected as changing parameters to conduct axial compressive tests of 30 concrete cylinders. The maximum loads, failure modes, load-displacements curves and load-strain curves were obtained. The increasing ratios of maximum loads corresponding to different strengthening methods, load-displacement curves of strengthened concrete cylinders, tensile process and failure mechanism of CFRP grid-sprayed mortar were analyzed. Based on the analysis of experimental results, the following main innovative results were achieved: (1) The tensile process of CFRP grid-sprayed mortar in strengthened concrete cylinders was divided into five stages; (2) The tensile failure mechanism of CFRP grid-sprayed mortar in strengthened concrete cylinders was revealed; (3) The confining effect of CFRP grid-sprayed mortar for concrete cylinders was revealed from the perspective of confining capacity and demand. It was shown that the ductility performance of concrete cylinders can be enhanced significantly by strengthening with CFRP grid-sprayed mortar.

Chapter 6 Conclusions. This chapter summarized the research results and proposed the conclusions.